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Inventory

New records of dragonflies and damselflies (Insecta: Odonata) from Amapá state, Brazil

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Abstract: The Odonata Order comprises one of the largest groups of aquatic insects, 7,000 species are described worldwide, with approximately 860 species registered in Brazil, around 14% of the global fauna known to date. However, there are still great gaps in the knowledge of Odonata fauna in many areas of Brazil. This study aims to present the results of the survey of Odonata species sampled in three counties in the state of Amapá. The state is located in the north of the country, inserted in the Amazon Biome. Odonata were caught between January and December 2018, with 472 specimens being sampled, belonging to seven families, 36 genera and 53 species. In total, 27 of the species found during the study correspond to new records for the state of Amapá. Due to the lack of information on the diversity of the Odonata order in Amapá, the list of species presented should serve as input for new studies contributing to the knowledge of the order in the state.
Keywords: *Inventory; Amazônia; Diversity; Fauna.*

Libélulas e donzelinhas (Insecta: Odonata) novos registros para o estado do Amapá, Brasil

Resumo: A ordem Odonata compreende um dos maiores grupos de insetos aquáticos, mundialmente são descritas 7.000 espécies, sendo que, para o Brasil estão registradas aproximadamente 860 espécies, algo em torno de 14% da fauna global conhecida até o momento. No entanto, ainda existem grandes lacunas no conhecimento da odonatofauna em muitas áreas do Brasil. Este estudo tem como objetivo apresentar o resultado do levantamento de espécies de Odonata amostradas em três municípios do estado Amapá. O estado se encontra na região norte do país, inserido no Bioma amazônico. As capturas de Odonata foram realizadas entre os meses de janeiro e dezembro de 2018, sendo amostrados 472 espécimes pertencentes a sete famílias, 36 gêneros e 53 espécies. No total, 27 das espécies encontradas durante o estudo correspondem a novos registros para o estado do Amapá. Devido à falta de informação sobre a diversidade da ordem Odonata no Amapá, a lista de espécies apresentada deve servir de aporte para novos estudos contribuindo com o conhecimento da ordem no estado.
Palavras-chave: *Inventário; Amazônia; Diversidade; Fauna.*

Introduction

The Odonata order comprises the second largest group of aquatic insects (Djikstra et al. 2014). In Brazil, the group has a great diversity of names, the most common being dragonfly, hyacinth and lava-bunda (Brasil & Vilela 2019). The immatures are aquatic, and the adult individuals are winged terrestrial, organisms with predatory habits, both in their larval and adult stages (Corbet 1980).

Dragonflies occur on all continents, with the exception of Antarctica (Trueman 2007). Worldwide, the order comprises about 7,000 species (Kalkman et al. 2008), the number of species of Odonata in the neotropical region is close to 1,800 (Von Ellenrieder 2009), in Brazil 860 species are known, representing about 14% of the global fauna (Pinto 2018), or approximately 50% of the neotropical species.

Because of their close relationship with the aquatic environment, insects of the order Odonata are strongly affected by the physical and chemical changes in these environments, and some species of the order have environmental and ecological specificities for their occurrence (Nessimian et al. 2008). In particular, the species of the suborder Zygoptera are those that demonstrate the greatest environmental restrictions (Monteiro-Junior et al. 2014, 2015, Oliveira-Junior et al. 2015). These characteristics allow the use of dragonflies as bioindicators of the health of water bodies (Ferreira-Peruquetti & De Marco 2002, Monteiro-Junior et al. 2015). Different factors have been affecting Odonata populations; according to Clausnitzer et al. (2009) one out of ten species of Odonata is threatened with extinction, among aquatic insects, dragonflies are one of the few organisms that have the conservation status evaluated in Brazil by ICMBIO and globally by IUCN.

Dragonflies are charismatic insects (Corbet 1999), easily observed and handled in the field (De Marco & Vianna 2005). Even so, only 29% of the Brazilian territory presents data on the Odonata order (De Marco & Vianna 2005). In recent years, several studies have been published, increasing even more the knowledge of odonatafauna in Brazil, especially in regions with lesser knowledge: Takiya et al. (2016) in the state of Ceará, Rodrigues & Roque (2017) in Mato Grosso do Sul, Dalzochio et al. (2018) in Rio Grande do Sul, Koroiva et al. (2020) in Amazonas, Santos et al. (2020) in the state of Sergipe.

With the exception of the states of Amazonas and Pará, which have established large groups of studies with aquatic insects, studies with Odonata are still scarce in the Brazilian Amazon. Among the states of the northern region, Acre, Amapá, Rondônia and Roraima have a high lack of knowledge about the order. Amapá has a large area of land destined for preservation, approximately 70% of its territory is protected environments (Oliveira 2010). Even with this large area preserved, the state has a high lack of knowledge for numerous groups; among them, the insects of the Odonata order stand out for the lack of information. Therefore, this study aims to present a list of Odonata species collected in three counties in the state, reporting a series of new occurrences.

Material and Methods

1. Study area

The collections were carried out in three counties (Table 1) in the state of Amapá, located in the Amazon region in northern Brazil (Figure 1). The climatic classification of the state according to Köppen is of the type Am (Tropical humid), the average annual temperature is 27ºC and the average rainfall is 3330 mm.

In Macapá, Odonata were collected in an environment of dry forest island (Ilha de Mata Seca), which according to Santos et al. (2013) is an area of less structural complexity, where the vegetation is small due to several factors. The part of forest sampled has approximately 6 Km^2 and is located in an urban area within the Campus Marco Zero of the Federal University of Amapá-UNIFAP. The Ilha de Mata has no connection with any water course; the collections of water when present are temporary, occurring more frequently in the rainiest period. Still in the county, collections were made in the Rio Curiaú Environmental Protection Area (Rio Curiaú APA). The APA has predominantly Cerrado areas, floodplain forest in addition to large extensions of flooded fields, and during the rainy season these environments flood completely and remain like this during much of the year (Chagas 1997). In Oiapoque, collections were carried out in the village of Clevelândia do Norte, which borders French Guiana. The village is located on the right bank of the Oiapoque River, about 5 km south of the urban area of the county. The environment is bordered by an area of primary forest, part of the Amazon Forest, and the dense forest of solid ground is predominant in the place. The sampling of Odonata in Porto Grande was carried out in the Amapá Forestry and Cellulose SA (AMCEL) area; the study region

Table 1. Location of points and type of environment sampled.

Sample Point	County of Sample	Type of sampling environment	Coordinates
P1	Macapá	Brazilian Cerrado	0°00’19.5”S 51°05’06.5”W
P2	Macapá	Brazilian Cerrado	0°00’18.5”S 51°05’14.0”W
P3	Macapá	Brazilian Cerrado	0°00’24.8”S 51°05’13.9”W
P4	Macapá	Lotic Environment	0°16’17.5”N 50°54’58.0”W
P5	Macapá	Lotic Environment	0°14’48.0”N 50°57’26.4”W
P6	Macapá	Floodplain	0°11’21.7”N 51°00’03.5”W
P7	Oiapoque	Lotic Environment	3°48’38.5”N 51°51’55.7”W
P8	Oiapoque	Lotic Environment	3°48’36.0”N 51°51’48.8”W
P9	Oiapoque	Lotic Environment	3°47’46.1”N 51°51’47.9”W
P10	Porto Grande	Lotic Environment	0°43’51.30”N 51°21’36.6”W
P11	Porto Grande	Lotic Environment	0°37’26.79”N 51°21’3.11”W
P12	Porto Grande	Floodplain	0°39’20.68”N 51°22’49.8”W

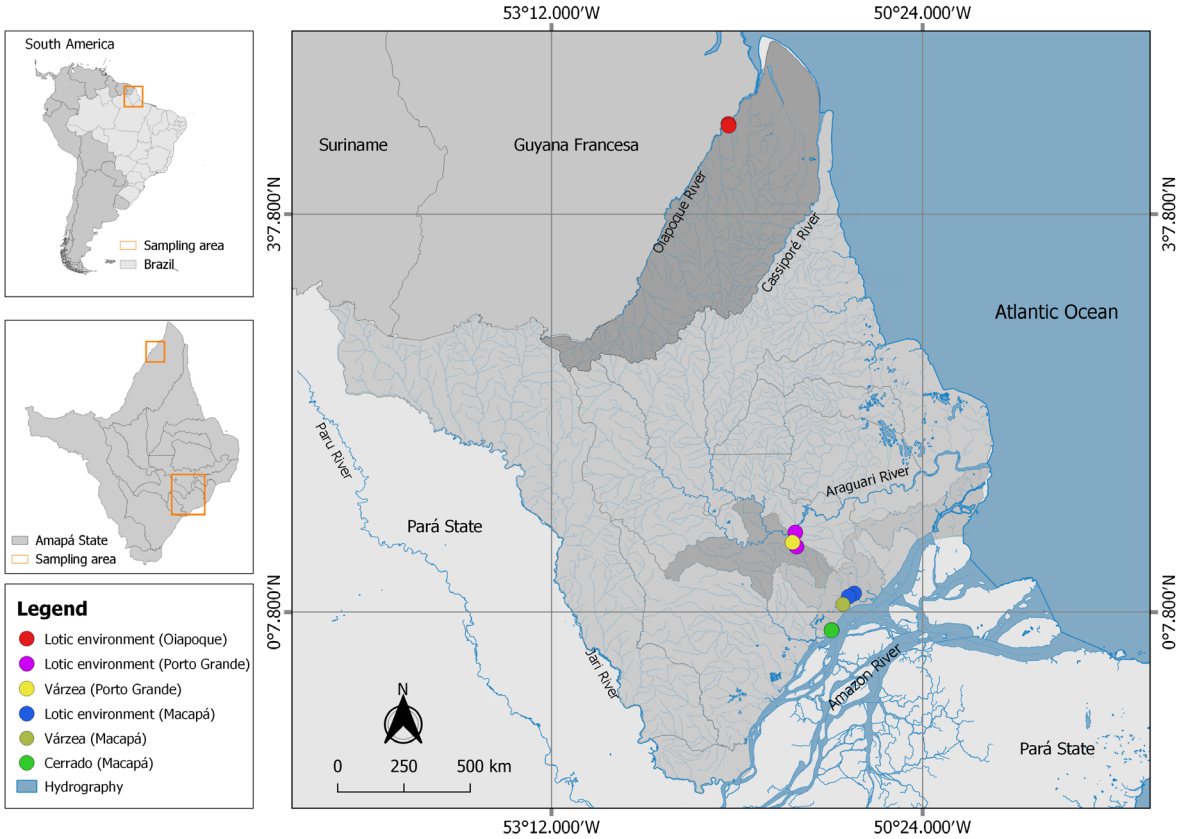

Figure 1. Map with the location of the counties of Macapá, Oiapoque and Porto Grande (AP) Brazil where the Odonata collections were carried out.

is formed by a mosaic comprising natural vegetation and extensive areas of monocultures, predominantly eucalyptus. According to Mustin et al. (2017) the natural vegetation occurring in the area comprises Amazonian savanna environments cut by stretches of gallery forests and flooded fields.

2. *Data collection*

The collections of Odonata were made between the months of January and December 2018. For the sampling of adults, entomological nets were used and the collections occurred between 10.00 and 16.00 P.M. of sunny days. The collected specimens were treated with acetone PA following the methodology proposed by Lencioni (2005), later identified according to the taxonomic keys of Garrison et al. (2006, 2010) and Lencioni (2005, 2006, 2017) for genera and species, and additional Anisoptera literature pertinent to each genera to identify at the species level. The collected specimens were deposited in the ArthroLab entomological collection at the Federal University of Amapá-UNIFAP.

3. *Statistical analysis*

To measure the sampling effort and number of species collected, the non-parametric Jackknife1 estimator was used, and the rarefaction curve was generated from the estimator. Jackknife 1 and the rarefaction curve were calculated using software R (R Core Team 2019) using the vegan package (Oksanen et al. 2019).

Results

In total, 472 specimens belonging to seven families, 36 genera and 53 species were sampled (Table 2), with 27 of the species found during the study corresponding to new records for the state of Amapá. Among the sampled families, Libellulidae showed the greatest diversity of species (n = 27), followed by Coenagrionidae (n = 17), Calopterygidae (n = 3), Aeshnidae, Gomphidae and Heteragrionidae (n = 2) and Dicteriadidae with one species.

The individuals of the suborder Anisoptera represented the greatest abundance of collected specimens (n = 280), followed by Zygoptera (n = 192). Among the Anisoptera, the family Libellulidae was the one that comprised the largest number of captured specimens (n = 269). The most abundant families among the Zygoptera were Coenagrionidae (n = 150), Calopterygidae (n = 26) and Heteragrionidae (n = 15). The most representative genera were *Erythrodiplax* (n = 67), *Ischnura* (n = 46) and *Orthemis* (n = 36). Among the sampled species *Miathyria marcella* (Selys in Sagra, 1854) (n = 29), *Erythrodiplax umbrata* (Linnaeus, 1758) (n = 28) and *Ischnura fluviatilis* Selys, 1876 (n = 24) were the ones with the highest number of collected individuals.

The rarefaction curve, based on the analysis of the data sampled during the study, showed good results for the sampling efforts, the collection efficiency was close to 84%. The Jackknife 1 estimator (Figure 2) demonstrated that the richness of species found corresponded to 73% (± 1,4).

Table 2. List of species registered for the state of Amapá. Location of the collection points present in table 1. ICMBIO red book status 2019, LC (Least Concern) and DD (Insufficient Data). * New records for the State.

Suborder / Family	Species	Collection points	ICMBIO Status
Zygopetra			
Calopterygidae	*Hetaerina amazonica* Sjöstedt, 1918	P10, P11	LC
	Hetaerina mortua Hagen in Selys, 1853	P8	LC
	Hetaerina moribunda Hagen in Selys, 1853	P10	LC
Coenagrionidae	*Acanthagrion amazonicum* Sjöstedt, 1918*	P4, P6	LC
	Acanthagrion egleri (Santos, 1961)*	P6	DD
	Acanthagrion kennedii Williamson, 1916*	P5, P6	LC
	Aceratobasis macilentum (Rambur, 1842)*	P6	LC
	Argia fumigata Hagen in Selys, 1865	P11	LC
	Epipleoneura kaxuriana Machado, 1985*	P5, P10, P11	LC
	Inpabasis rosea (Selys, 1877)*	P10	LC
	Ischnura capreolus (Hagen, 1861)	P1, P6, P4, P9, P10, P9	LC
	Ischnura fluviatilis Selys, 1876	P5, P6, P7, P12	LC
	Homeoura nepos (Selys, 1876)	P5, P6	LC
	Mecistogaster lucretia (Drury, 1773)*	P9	LC
	Neoneura bilinearis Selys, 1860*	P7, P8	LC
	Phasmoneura exigua (Selys, 1886)*	P10	LC
	Phoenicagrion flammeum (Selys, 1876)	P4	LC
	Psaironeura tenuissima Selys, 1886*	P7, P9	LC
	Telebasis carminita Calvert, 1909	P4, P6	LC
	Telebasis griffinii (Martins, 1896)*	P6	LC
Dicteriadidae	*Heliocharis amazona* Selys, 1853*	P8	LC
Heteragrionidae	*Heteragrion ictericum* Williamson, 1919*	P7, P8, P11	LC
	Oxystigma petiolatum (Selys, 1862)*	P10	LC
Anisoptera			
Aeshnidae	*Coryphaeschna adnexa* (Hagen, 1861)*	P6	LC
	Gynacantha mexicana Selys, 1868*	P3, P5, P10	LC
Gomphidae	*Aphylla janirae* Belle, 1994*	P5	DD
	Phyllocycla sp.	P8	LC
Libellulidae	*Anatya guttata* (Erichson in Schomburgk, 1848)*	P1, P3, P4	LC
	Brachymesia herbida (Gundlach, 1889)	P1, P2, P9, P11, P12	LC
	Diastatops obscura (Fabricius, 1775)	P5, P7, P8, PP11	LC
	Diastatops dimidiata (Linnaeus, 1758)*	P8	LC
	Erythemis peruviana (Rambur 1842)	P2, P3, P8, P11	LC
	Erythemis vesiculosa (Fabricius, 1775)	P1, P2, P6, P7, P11	LC
	Erythrodiplax basalis (Kirby, 1897)*	P5, P7, P8	LC
	Erythrodiplax famula (Erichson in Schomburgk, 1848)	P3, P12	LC
	Erythrodiplax fusca (Rambur, 1842)	P2, P5, P8, P11, P12	LC
	Erythrodiplax umbrata (Linnaeus, 1758)	P2, P3, P9, P11, P12	LC
	Erythrodiplax unimaculata (de Geer, 1773)	P6, P10, 12	LC
	Miathyria marcella (Selys in Sagra, 1857)	P1, P2, P9 ,P12	LC
	Nephepeltia flavifrons (Karsch, 1889)	P4, P6	LC

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Nephepeltia phryne (Perty, 1834)*	P5	LC
Orthemis attenuata Erichson in Schomburgk, 1848*	P9	LC
Orthemis concolor Ris, 1919*	P2, P3, P7, P10	LC
Orthemis discolor (Burmeister, 1839)	P1, P6, P9, P10, P11, P12	LC
Orthemis sulphurata Hagen, 1868	P3	LC
Pantala flavescens (Fabricius, 1798)	P3, P6, P7, P11	LC
Perithemis lais (Perty, 1834) *	P4	LC
Tholymis citrina Hagen, 1867*	P3, P8, P10	LC
Tramea calverti Muttkowski, 1910	P1, P8, P10, P11	LC
Tramea rustica DeMarmels & Rácinis, 1982	P6	LC
Uracis fastigiata (Burmeister, 1839)*	P5, P8, P10, P11	LC
Uracis ovipositrix Calvert, 1909	P7, P8, P10	LC
Zenithoptera fasciata (Linnaeus, 1758)*	P3, P6, P7, P11, P12	LC
Zenithoptera viola Ris, 1910	P6, P10	LC

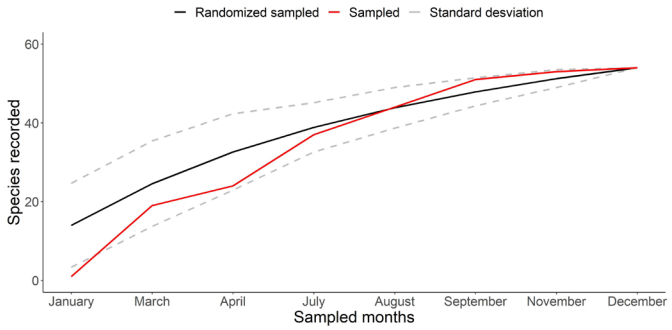

Figure 2. Rarefaction curve and its confidence interval (95% CI) of Odonata species collected in the counties of Macapá, Oiapoque and Porto Grande (AP), Brazil.

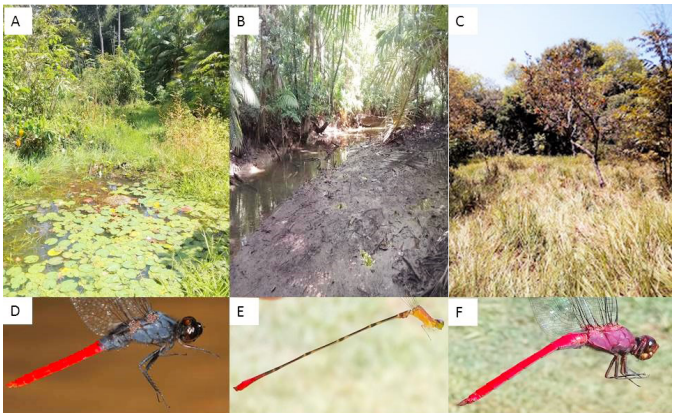

Figure 3. Sample locations: A, Macapá, Rio Curiaú Environmental Protection Area - APA do Curiaú; B, Porto Grande, Amapá Forestry and Cellulose SA (AMCEL); C, Macapá, Ilha de Mata seca in the Amazon savanna. Odonata: D, Libellulidae, Erythemis peruviana (Rambur, 1842); E, Coenagrionidae, *Psaironeura tenuissima* Selys, 1886 and Libellulidae, F, *Orthemis discolor* (Burmeister, 1839).

Discussion

The study was carried out in a small sample area in three counties in the state of Amapa; in total 53 species were found, a result that suggests that the region's Odonata fauna is relatively richer. Representatives of the suborder Anisoptera comprised approximately 60% of the samples sampled, with 280 specimens collected, the Libellulidae family (n = 269) was the most abundant during the study. This high number can be explained by the fact that many species of this family are opportunistic organisms (Costa & Oldrini 2005, Boti et al. 2007), frequently prevalent in open vegetation environments (Dutra & De Marco 2015, Rodrigues & Roque 2017) or even in anthropized environments (Damaceno et al. 2014). This fact is due to its ability to control body temperature (Corbet & May 2008), in addition to having great dispersion capacity (Monteiro-Júnior et al. 2013, Oliveira Júnior et al. 2017).

The families Aeshnidae and Gomphidae had only two species collected each, totaling 11 individuals sampled, eight specimens belonging to Aeshnidae and three to Gomphidae.This low number can be associated with the flight habits of these organisms, which are usually extremely fast. In addition, species of Aeshnidae usually reach great heights and some species are crepuscular (Bedê et al. 2000), a fact that makes it difficult to capture them. According to Almeida et al. (2013) these low numbers may be linked to the type of collection performed, a diversification of sampling methods may allow obtaining species rarely captured using the standard methodology.

Coenagrionidae, the family with the largest number of species for the suborder Zygoptera in Brazil (Lencioni 2006), presented the greatest diversity of species (= 17) and abundance (n = 150) among zygopterans, with almost 78% of the collected specimens. The genera *Ischnura*, *Acanthagrion* and *Telebasis* with 46, 22 and 22 individuals collected respectively were the most abundant for the family, comprising approximately 60% of the Coenagrionidae sampled. The specimens of these genera are highly representative organisms in many studies and in different environments such as: (Cerrado, Ferreira-Peruquetti & Fonseca-Gessner 2003, Borges et al. 2019; Veredas, Vilela et al. 2016; Pampa, Garcia Junior et al. 2019; Atlantic Forest, Ferreira-Peruquetti & De Marco 2002).

With the exception of *Oxystigma petiolatum* (Selys, 1862) (Heteragrionidae) and *Mecistogaster lucretia* (Drury, 1773) (Coenagrionidae) found exclusively within the forest area during this study, the other specimens of zygopterans were collected close to water bodies, generally in shaded areas. This fact can be attributed to ecophysiological restrictions of the group (Corbet 1999). These organisms generally have a small size, which represents a high conductance, so they tend to look for places with less thermic variation, such as places with less sunlight (Brasil et al. 2019).

Most of the species found during the study, according to De Marco et al. (2018) in the red book of Brazilian fauna threatened with extinction fall into the level of least concern. However, *Aphylla janirae* Belle, 1994 and *Acanthagrion egleri* (Santos, 1961) are species that have insufficient data to classify the level of vulnerability; these new distribution records may contribute in the future to the threat level of these species.

In conclusion the diversity of Odonata found and the report of the new occurrence records for the state indicate that the fauna of the region deserves more attention, and the establishment of new collection points can further expand the list of species occurring in Amapá.

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Author Contributions

Manoel Daltro Nunes Garcia Junior: Substantial contribution in the concept and design of the study. Contribution to data collection. Contribution to data analysis and interpretation. Contribution to manuscript preparation. Contribution to critical revision, adding intellectual content.

Monique Telcia dos Santos Damasceno: Contribution to data collection. Contribution to manuscript preparation.

Maria Jeovana Lima Martins: Contribution to data collection. Contribution to manuscript preparation.

Tiago Silva da Costa: Contribution to data analysis and interpretation. Contribution to manuscript preparation. Contribution to critical revision, adding intellectual content.

Ricardo Marcelo dos Anjos Ferreira: Contribution to data analysis and interpretation. Contribution to manuscript preparation. Contribution to critical revision, adding intellectual content.

Raimundo Nonato Picanço Souto: Substantial contribution in the concept and design of the study. Contribution to data analysis and interpretation. Contribution to manuscript preparation. Contribution to critical revision, adding intellectual content.

Conflicts of Interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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